Space Weather Technical Forecast

Issued on Monday, 20 December 2021 at 00:35 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor storms early day 1 (20th), but soon easing. Chance of M-flares. Chance of Active electron Fluence.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar Activity is currently Low, with a number of small C-class X-ray flares observed, with peak of C3.7 from AR2907. There are currently seven numbered sunspot regions and three further unnumbered regions on the disc. The most prominent is AR2907 Csi/Beta-gamma in the southern central disc, although this has shown some decay in its lead spot, despite a reverse polarity region near its trailer. This is followed by two further regions AR2908 Cso/Beta and AR2909 Cao/Beta, both of which have been gradually showing signs of decay. All other regions are either small unipolar or bipolar regions, with limited flare risk, but situated within areas of plage giving the potential for further development. No Earth-directed CMEs have been observed in available imagery.

Solar Wind / Geomagnetic Activity: Solar winds, as measured by the DSCOVR satellite at L1, rose since 19/1210 UTC from background levels of below 350km/s to be slightly elevated at just over 450km/s. This was accompanied with density rising from average levels to peak around 52 ppcc at 19/1735 UTC, before declining to average or just above average levels. The Interplanetary Magnetic Field Strength (IMF), Bt also rose from weak values near 5nT, to peak 24nT at 19/2035 UTC. This was associated with Bz also strengthening but becoming variable, ranging +15nT to -20nT, with peak southward (negative) component at 19/2038 UTC. The phi angle was predominately negative throughout (towards the Sun). These parameters were the result of a strong CIR region arriving ahead of the transition into the fast wind of CH36. Geomagnetic activity was Quiet at first, but increased to be Active from 19/1800, with a G1/Minor Storm interval at 19/2100-2400 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) was at mainly Background levels, with the associated 24-hour integrated fluence well below the Active threshold. A fluence of 5.28e6 was observed at 19/2100UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to continue mainly Low, with the Chance (25%) of isolated M-class flares, predominately from AR2907 but cannot be ruled out from the other sunspot regions on the disc given further development. There are also a number of filaments visible in H-alpha imagery and whilst stable, they will need monitoring for any potential lift.

Solar Wind / Geomagnetic Activity: There are no Earth-directed CMEs. Current slightly elevated solar winds from the fast wind of CH36 are expected to persist day 1 (20th), perhaps strengthening further. These remain slightly elevated to elevated days 2 and 3 (21st and 22nd) with the transition into the fast wind of CH35, before easing later in the period. Unsettled to Active geomagnetic activity is expected at first, with a chance of G1/Minor Storms, easing to Quiet with Unsettled periods, and a chance of isolated Active intervals through days 1-3 (20th-22nd). Mainly Quiet day 4

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(23rd).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels and below the S1 level, although there is the potential for some increased flux from any flare activity, primarily from AR2907. The high energy electron flux is forecast to be at background at first, but rising days 1-3 (20th-22nd) due to recent solar wind enhancements from the arrival of the fast wind of CH36. Peak flux is likely to reach High levels (1000 pfu), but brief some drop outs are possible as any further enhancement from CH35 arrives. Persistently high flux is possible by day 4 (23rd). The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold until at least day 2 (21st) with a chance of then rising above. Whilst this risk increases through the period, it remains low confidence.

Figure 1: Observed Solar Winds, showing clear CIR enhancement.

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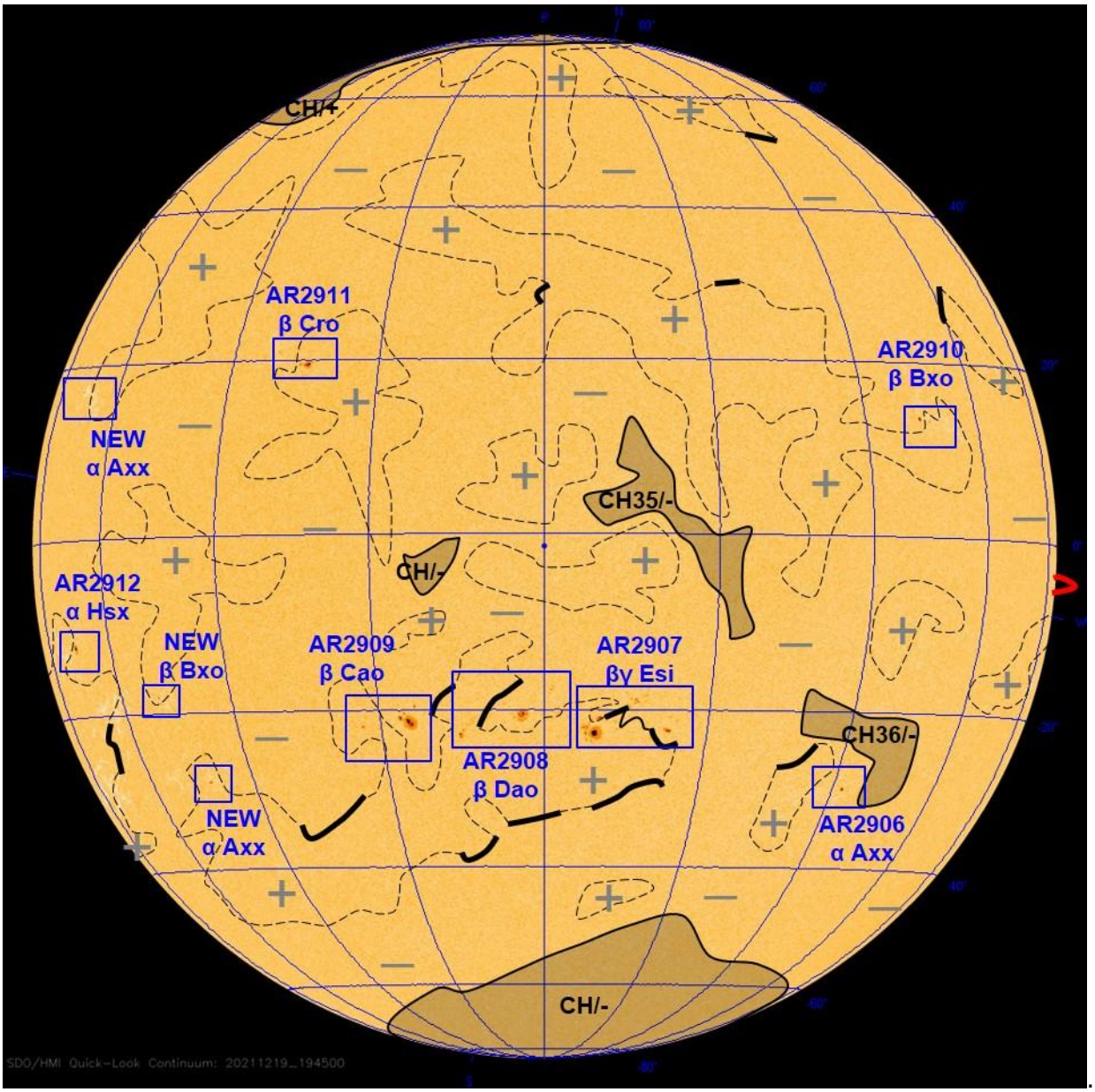
Figure 2. Solar Analysis Valid 19/2000 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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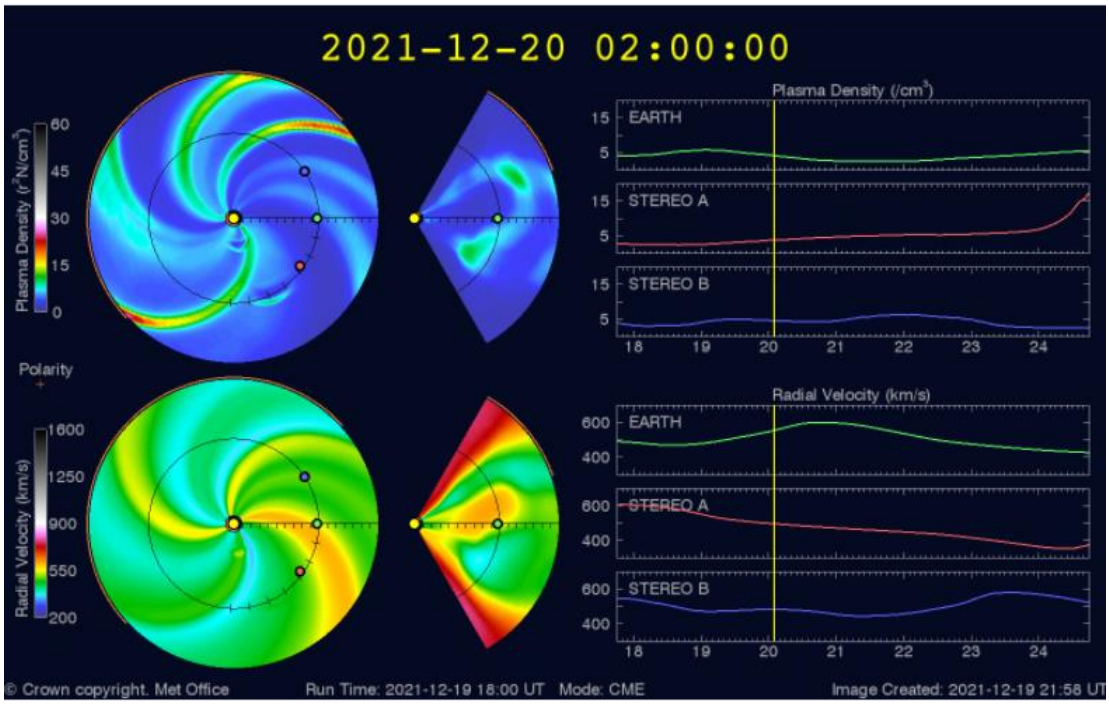
Geomagnetic Storms:

There are no Earth-directed CMEs. Earth has recently connected the fast wind of CH36, with solar winds becoming slightly elevated. This winds are expected to increase further day 1 (20th), before a subsequent transition into any associated fast wind of CH35 follows, leading to a period of slightly elevated to elevated solar winds until day 3 (22nd). This transition most likely later day 2 or early day 3 (21st-22nd). Solar winds then easing day 3 (22nd) onward. This is supported by Enlil and 27-day persistence which shows a fast wind enhancement until day 3 (22nd), and then easing.

Geomagnetic activity is forecast to be Unsettled to Active with a chance of G1/Minor Storms at first easing to Quiet with Unsettled periods, and a chance of isolated Active intervals through days 1-3 (20th-22nd), and then mainly Quiet day 4 (23rd).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	30	5	5	1
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Figure 3: Enlil showing period of elevated solar winds in-line with forecast



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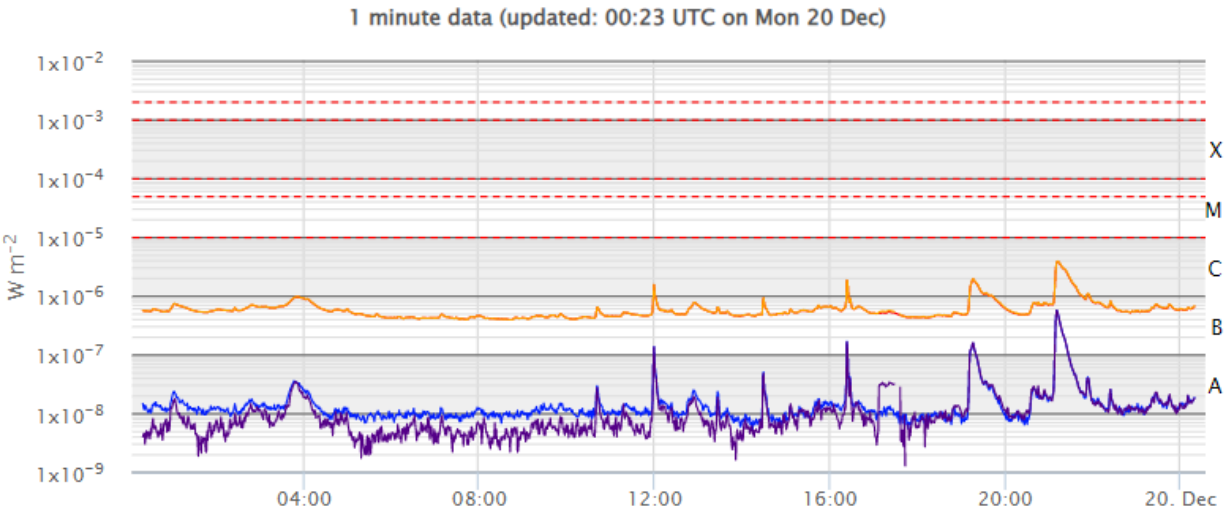
Radio Blackouts - X-Ray Flares:

There are currently ten sunspot containing active regions on the Earth-facing disc, however all are either small and simple, or showing signs of simplification and dissipation. The most notable region is AR2907 Csi/beta-gamma in the centre disc, which was the source of a C3.7 at 03/2124UTC. This has maintained a positive polarity spot near its main negative trailer, despite its lead spot having now lost its penumbra and showing signs of dissipation. AR2908 Cso/Beta and AR2909 Cao/Beta follow this region in the southern centre disc but are both showing signs of gradual decay. AR2911 Cso/Beta in the northeast, was the source of an M-flare on the 17th, but is currently small and simple. All other regions are a mixture of small unipolar or bipolar region amongst larger plage regions.

With all regions either small, or showing signs of decrease, solar activity is forecast to remain Low, with further C-flares expected. There is a chance (25%) of isolated M-class flares.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	25	25	25	25
Very Active	R3 to R5 X Class	No	2	2	2	2

Figure 4: GOES 16/17 Observed X-ray flux



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Solar Radiation Storms - (High Energy Protons):

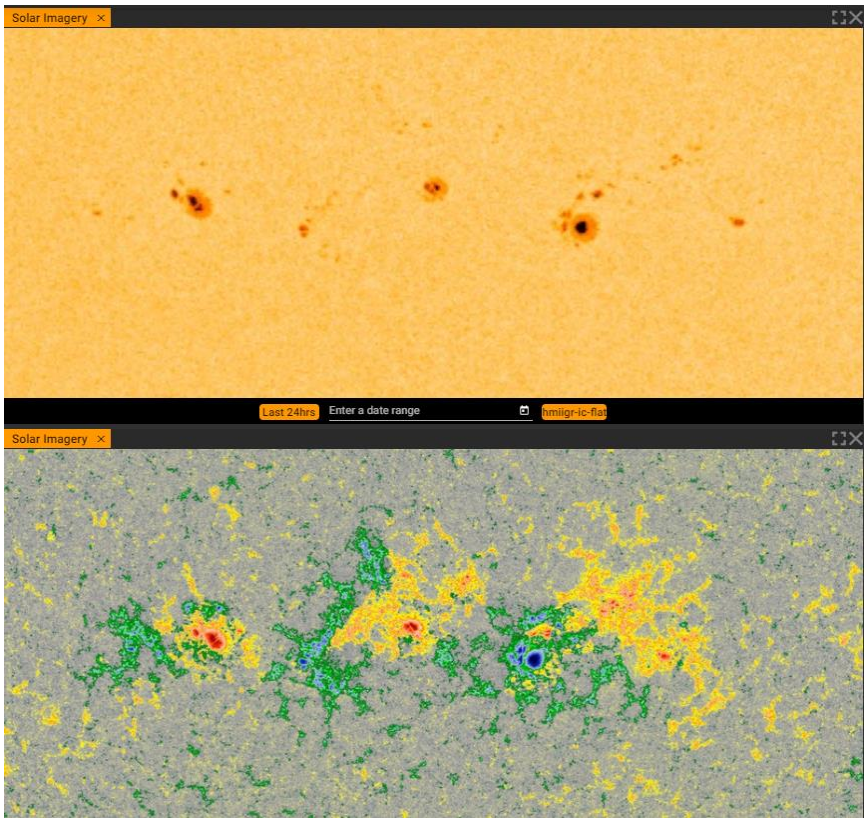
The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is currently at Background levels.

Despite the large number of sunspots on the disc, a number of which are now moving into an improved geoeffective location for radiation storms, their small size and simple magnetic structure means that proton rich flaring is unlikely. Background levels are expected to persist, with a slight chance of some small increases from any notable flares that do occur. There is only a very slightly above background risk of rising to the S1 alert level.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

Figure 5: SDO hmi-intensitygram and magnetogram of the main central region of sunspots (AR2909, AR2908 and AR2907 respectively). Regions appear simple now, with main complexity in AR2907



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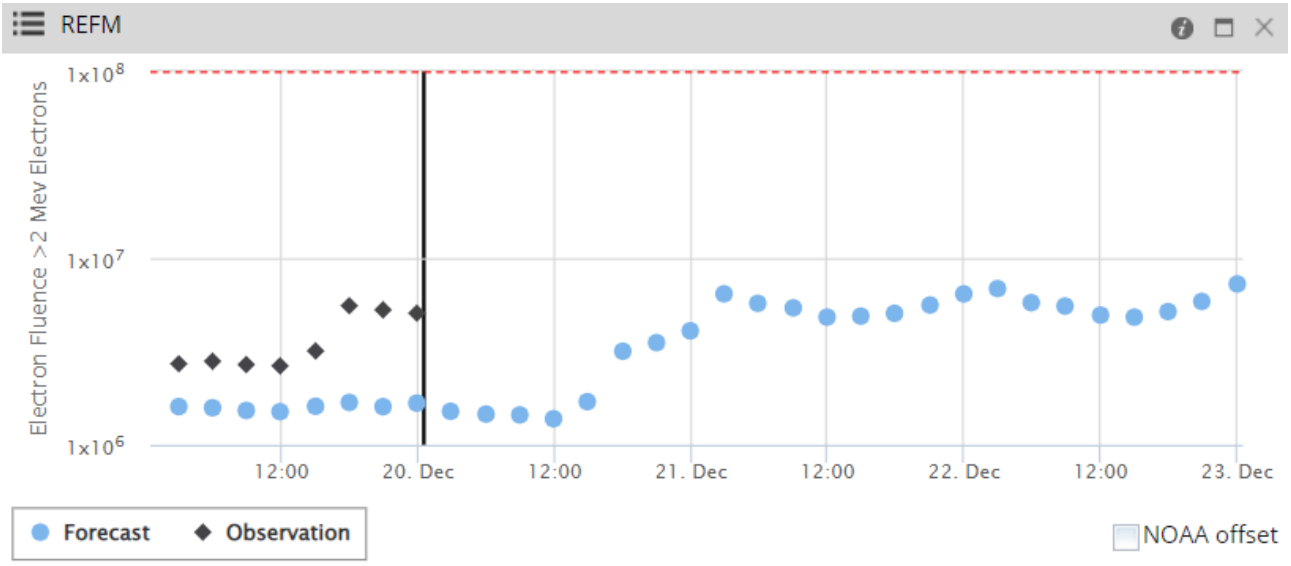
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed by GOES-16 is currently at background, but likely to increase as a result of recent fast wind enhancements from coronal hole 36. Once early geomagnetic activity on day 1 (20th) eases a gradual build of observed flux is likely, peaking at High levels (above 1000 pfu). Further enhancement from any arrival of fast wind from CH35 on day 2 and 3 could bring dropouts to the observed flux, before Moderate to High levels are expected to resume. This enhancement is currently uncertain however, giving low confidence to the forecast by day 3 and 4 (22nd and 23rd).

The associated 24 hour fluence is expected to remain below the Active (1e8 integrated pfu) threshold until at least day 2 (21st) with a chance of then rising above. Whilst this risk increases through the period, it remains low confidence due to uncertainty around the strength of any enhancement from CH35. REFM is currently giving poor guidance as this currently doesn't take account of the solar wind enhancement that is ongoing at time of issue.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	30	30	40
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 6: GOES-16 Electron fluence with REFM.



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